SPACE PHOTOGRAPHY OF SOME OCEANIC PHENOMENA AND COASTAL PROCESSES[1/]

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Introduction

The world ocean is a dynamic system covering 71 percent of the earth's surface. The lack of synoptic data from the world ocean limits the oceanographer in understanding the processes producing many observable oceanic phenomena. Most of the existing explanations of oceanic features are conjectural because of the limited number of observations made using conventional techniques. Such observations are not proving fruitful in the development of new knowledge of the interrelationships of the ocean-atmosphere-land system.

The inadequacy of current synoptic data-gathering systems becomes apparent when viewed from the standpoint of time. The unique advantage of the satellite for oceanic studies is the capability of real-time synoptic coverage of the earth's surface. Furthermore, the coverage is rapid and repetitive, thus eliminating the major constraints to the measurement of oceanic phenomena; i.e., the vastness and remoteness of the world ocean and its time variant features. The fundamental problem today is how to acquire truly synoptic data in a usable, valid, and operational time frame. The problem can now be solved by the "view-from-space," for all major oceanographic phenomena can be measured by one or more of a combination of "on-the-shelf" remote sensors.

Coastal Processes in the Laguna de Terminos (Figure 1)

Laguna de Terminos is approximately 42 statute miles in length and 18 statute miles wide. The Laguna and surrounding land comprise about 3,300 square miles in the field of view of this photograph.

The direct utility of space photography to the study of coastal oceanographic phenomena is apparent from this photograph. The photographic situation is quite optimal here in that the Gulf water is clear and calm, and the colloidally suspended and current rafted material is light in color. Under these conditions of contrast, several active coastal processes are readily viewed at one instant in time.

Laguna de Terminos is a topographically low indentation in the Yucatan Peninsula. A series of small, fringing marshes and lagoons are evident around the major lagoon. These areas are slowly being filled with sediment from the three river systems evident on the photograph. The mud flats and associated brackish-water bodies support a mangrove type of vegetation.

This photograph was taken in August 1965, when the region was experiencing a period of maximum rainfall. Large quantities of detrital and colloidal suspended material were being discharged into the ponds and lagoons as well as Laguna de Terminos. The low relief of the Yucatan Peninsula and the soluble surface material extant preclude the accumulation of any sizable quantity of sand. The Laguna was, therefore, slowly filling with a light-colored, calcareous mud with intermixed silty and fine sand material. Most of this material can only be deposited in the Laguna during the period of intermediate to low tide when the fringing ponds and lagoons can empty into the Laguna. This process can be seen in action on the photograph. Note the two discharge channels from Rio Palizada (southwest) through which material was flowing at that instant. This easily detected pattern is one means of determining the direction of flow of the water.

Movement of water leaving the Laguna creates a turbulence which induces a scouring action on the Laguna bottom and in the inlet channel, and disperses the colloidal particles into the offshore waters. The eastern channel is the primary inlet for the flood waters, noted by the buildup of deltaic bars. Most of the Laguna discharge flows through the western channel. As a consequence, less turbulence occurs in the eastern portion of the Laguna, and the fresh water entering from the Rio Pargos is evident in this area.

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The most obvious action depicted on the photograph is the discharge of water and sediment through the western channel. The tidal velocity at this time was not of sufficient magnitude to overcome effects of the westerly longshore current. Tide tables show that at the time of the photograph (1409 hours) the tide was ebbing from a high of 2.7 feet at 0214 hours to a low of 0.6 feet at 1637 hours. Tonal variation in the photograph makes it quite easy to follow the sequence of events during this tidal recession.

The westerly longshore current was transporting sediments to the west while some of the colloidal material was carried farther out in the Gulf where it was less effected. An interesting countercurrent, or eddy, developed above the left end of Isla del Carmen.

Sandbar development can easily be seen along the coast to the right of the east channel. These bars are developed and oriented by incoming waves and longshore currents reacting on the silts and sands forming the Gulf floor at this locality. This detrital material is being transported to the west. Sandbar migration is one type of sedimentary transport induced by current and wave action. These bars have developed in water about 12 feet deep.

The coastal area between Rio de San Pedro and San Pablo, the western channel, and the central portion of the Isla del Carmen distinctly shows the structural remnants of high water and wind action. These structural lineaments paralleling the coast are sand ridges (beach ridges) with intervening troughs containing sufficient soil to support assorted vegetation including palm trees.

Texas & Louisiana Currents & Coastal Processes
(Figure 2)

The Texas and Louisiana Gulf coast is a particularly shallow shelf region with the water attaining 300 feet in depth as far offshore as 80 nautical miles.

Water-mass buildup in the Texas Gulf region is related in part to the duration and force of the prevailing southeasterly and sporadic northeasterly winds.

This photograph depicts conditions existing in the region 2 days after the passing of a cold front with the winds continuing to blow out of the northeast at 10-15 knots.

Winds accompanying the passing cold front provide sufficient force to partially drain the estuaries and lagoons within the region. Such action is shown by the light brown, sediment-laden waters being driven out of Sabine Lake and Galveston Bay. Sediments are being transported southwest along the coast by the wind-induced longshore current.

Lighter colored colloidal material has been carried further offshore by the relatively turbulent water of the Gulf and the several frictional eddies extending along the shallow shelf. The large eddylike structures are major oceanic features and are similar to rip currents in that they are "relief currents" of water piled up against the shore of the northwest Gulf.

The significance of being able to photograph repeatedly coastal waters is clear. This is especially so in these waters in which lie the greatest shrimp fishery in the world. Two key events in the lives of these shrimp are their migration to the coastal estuaries as postlarvae, and from the estuaries as juveniles and adults.

An analysis was made of the amounts and locations of shrimp caught during this period in November. This study revealed that the shrimp were caught directly beneath, or within, the major eddylike, or rip-current features. Additionally, a few shrimp were caught in the lee of the interference eddy immediately west of the Galveston jetties.

It is significant then, to be cognizant of all current systems within an area at all times to adequately predict the potential locations of various fisheries.

Quite clearly, the recognition and monitoring of such large-scale features can only be derived from recordings of the great overview unique to orbiting vehicles.

Upwelling and Taiwan
(Figure 3)

The major current system in the western Pacific Ocean flows from south to north past the island of Taiwan. Around the island, and especially in the Formosa Straits, the currents are complicated by the tides which ebb to the south along the southwestern shores of Taiwan.

On July 19, the day before this photograph was taken, tropical storm "Nina" was about 90 nautical miles east of Taiwan. The storm was not well developed and winds of Beaufort Force 3 were the highest recorded. By 1200 hours

(GCT), July 20, the storm had dissipated and winds of Force 2 blew around Taiwan from an easterly direction.

In the photograph, the light blue of the sea is the result of a diffuse sun's reflection from an evenly roughened sea surface. Winds from the east and northeast increased the roughness of the northerly flowing waters. The reflective, specular pattern from the sea surface thus depicts the features of water motion around the southern end of Taiwan.

The major current is parted by the island much as a ship parts the water. As the "bow" wave spreads from the island, upwelling must take place near the shore. The dark blue water masses east and west of the island represent the areas of major upwelling.

Areas of upwelling are known to provide nutrient waters for some fisheries. The fishing ports along the west coast of Taiwan are concentrated north of the lagoonal complex on the southwest coast. Quite possibly this photograph shows for the first time that phenomena which may be responsible for the support of the Taiwan fisheries.

A detailed oceanographic survey of the southwest coast shown here should provide conclusive data as to the relation of the upwelling area and the Taiwan fisheries.

Robert E. Stevenson received his bachelor degree from UCLA in 1946, masters from UCLA in 1948 and doctorate from the University of Southern California in 1954. From 1953 to 1961 he was the Director for Inshore Research at the Allan Hancock Foundation, University of Southern California. In 1961 he came to Texas as research scientist in the Department of Oceanography and Meteorology at Texas A & M University and in 1962 became Director of the A & M Marine Laboratory in Galveston. In 1963 he joined the staff at Florida State University as research associate in the Oceanographic Institute, Associate Professor in the Department of Geology, and Associate Professor in the Department of Meteorology. He then left Florida in 1965 to accept a position at the Bureau of Commercial Fisheries in Galveston where he is now the Assistant Laboratory Director.

Convergence Phenomena
Florida, Cuba, and Bahamas
(Figure 4)

The spacecraft doors were open and Lt. Col. Aldrin was standing on the cockpit seat as he photographed southern Florida, the western portion of the Bahama Banks, Cuba, Yucatan (on the horizon), and portions of the Caribbean Sea and the Gulf of Mexico.

Sun angle is a very significant factor in the sensing of oceanic phenomena. In this photograph the glitter pattern of the sun's reflection enhances the surface expression of an area of divergence paralleling the west coast of Florida. The diffuse reflection is a result of a roughened water surface while the elongated darker blue area of convergence represents a smoother water surface.

The existence of the divergence feature seen here has been suspected for some time and has been examined in part by oceanographers using standard oceanographic survey methods. The great size, configuration, and accurate positioning of such a feature can only be recognized and accomplished by using the overview provided by the spacecraft and the recognition and data gathering by a trained observer. A convergent feature such as this is most significant to commercial fisheries throughout the world ocean. Such conditions are particularly significant within the north and south 40° latitudes.

James S. Bailey received his PhD degree in Engineering Geology from the University of Arizona in 1955. Since that time he has conducted research for a major oil company and recently served as geological oceanographer for the NASA/Navy, Space Oceanography Project. He is now with the Bureau of Commercial Fisheries in Galveston, Texas, and is project leadur for the Space Applications to Fisheries Oceanography Project.